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Successful Movement of Post-smolt Atlantic Salmon from River Estuaries to the Bay of Fundy

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Atlantic salmon escapement in Atlantic Canada has markedly declined in many rivers of the Bay of Fundy in recent years. The hypothesis of increased natural mortality in the marine environment has been raised to explain the declines in Atlantic salmon stocks that are occurring in both North America and Europe. However, there is yet no direct evidence of this mortality nor identification of the factors that may be responsible. There is a general lack of knowledge of the migratory behavior and survival of salmon at sea because of the difficulties in keeping track of fish at sea compared to those in rivers. The need for information is especially true of post-smolts during their seaward migration, a period when mortality may be very high. The study reported on here is a first step toward addressing these questions.

In 1995, a novel study was conducted by the St. Andrews Biological Station in collaboration with the Atlantic Salmon Federation to monitor the movement of Atlantic salmon smolts during the early stage of their seaward migration in coastal areas

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Atlantic Salmon Growth in Bay of Fundy Sea Cages

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In the spring of 1995, we initiated a project to study salmon production on 20 salmon farms in the Bay of Fundy, in collaboration with D.J. Wildish of the St. Andrews Biological Station, G. Steeves of the Bedford Institute of Oceanography, and the New Brunswick Salmon Growers' Association. The project was designed to follow one year class of smolts from entry into the cages until they were marketed. Three cages are monitored at each of the 20 farms. VEMCO recording thermometers programmed to record temperatures at half-hour intervals are installed at each site. A dual camera system was designed and fabricated to periodically measure fish sizes in the monitored cages. Information is being collected on cage types and volumes; feeding procedures; feed types, sizes, and volumes; and mortalities. Flushing characteristics at each site are being estimated by the gypsum cylinder dissolution method. A sample of 20 smolts was purchased from each shipment destined for the cages to be monitored, collecting them from the transport trucks prior to placement in the cages. The smolts were analyzed for fin condition, length, weight, sex, presence of adhesions, gonad size, and salinity tolerance. Fish size in each cage was measured once in the summer of 1995, and will be measured again in the summer of 1996. Samples of fish marketed from each of the monitored cages will be sexed, weighed, measured, and checked for maturation state and incidence of adhesions. The data will be used to assess factors affecting production performance in the monitored cages and develop growth and production models.

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(Successful Movement of Post-smolt Atlantic Salmon continued)

of the Bay of Fundy using ultrasonic telemetry. Miniature acoustic pingers that emit low frequency sound pulses were surgically implanted in the abdomens of 96 hatchery-reared smolts while in freshwater. Groups of 48 smolts with pingers were then released at the head of tide in the St. Croix and Magaguadavic rivers at the time of natural smolt migration in May.

The movement of smolts from the rivers into Passamaquoddy Bay was monitored with an automated pinger detection unit moored underwater at the mouth of each river. Each unit had a radius of detection in excess of 0.25 nautical miles. Movement of post-smolts from Passamaquoddy Bay into the Bay of Fundy was then monitored using a network of 10 automated pinger detection units placed to cover all outlets from Passamaquoddy Bay (Figure 1). These units were moored at depths of up to 90 m in areas of extreme tidal currents. Each unit could detect individual pingers according to their pulse code and then could store the time of passage of a tagged fish in a memory.

The efficiency of the network of underwater pinger detection units at detecting the passage of individual fish was excellent. Post-smolts were usually detected by at least two units when moving out of Passamaquoddy Bay. Searches for fish were also made daily during June by crews on three boats equipped with receivers for pinger location and tracking. In addition, surveys were made to detect if post-smolts were caught in the many herring weirs along the coast and to determine if post-smolts were attracted to or affected by the presence of numerous marine cage sites for the culture of Atlantic salmon in the Passamaquoddy Bay area.

Smolts, which are called post-smolts upon entry into saltwater, rapidly left the release sites. Most moved down the estuaries and into Passamaquoddy Bay in 1-2 days. 90% of the smolts released in the Magaguadavic River and 94% of those released in the St. Croix River were detected upon entering Passamaquoddy Bay, indicating that mortality in the river estuaries was very low. Post-smolts were then frequently detected during searches by boats over a period of several weeks as they moved into the Bay of Fundy. Some fish from each of the rivers moved seaward out of Passamaquoddy Bay within 3 days of release, and the majority had left the bay within 7-10 days.

The migration routes used by post-smolts after leaving the rivers were determined from position fixes of fish detected throughout Passamaquoddy Bay and site of detection upon leaving the bay. Fish from the St. Croix River moved straight down the estuary and then 60% of the fish released moved into Western Passage whereas 28% moved out through Letete and other passages after moving along the shoreline of Deer Island. Few fish from the Magaguadavic River (8%) moved out directly through nearby Letete Passage, and the majority of fish (63%) moved counterclockwise along the shoreline of Passamaquoddy Bay and left through Western Passage. This indicated that post-smolts were probably migrating in the top water layer and that they moved with the aid of surface currents which were counterclockwise inside Passamaquoddy Bay in spring and early summer.

Figure 1

Although some post-smolts left by all of the passages from Passamaquoddy Bay into the Bay of Fundy, the majority of these left through Western Passage. The initial movements of fish through this narrow passage which has strong tidal currents were largely influenced by the state of the tide, and several tidal cycles were often required for a fish to exit the passage and enter the open waters of the Bay of Fundy. Some post-smolts were also tracked moving into the Bay of Fundy, up to several kilometers off of Campobello Island.

Overall, 80% of the post-smolts were detected successfully leaving Passamaquoddy Bay, indicating that survival during this first stage of seaward migration was much higher than previously considered (Figure 2). The period of migration when post-smolts are in coastal areas where predators are abundant and where obstacles to migration are often present was thought to result in high mortality but this study indicated otherwise. More post-smolts from the St. Croix River than from the Magaguadavic River (88% vs. 71%) made it out of Passamaquoddy Bay. The lower survival of fish from the Magaguadavic River was possibly related to their migration route which took them into many of the small bays and coves of upper Passamaquoddy Bay. Five fish from that river ended up in herring

Figure 2

Figure 3

weirs; three found their way out but two post-smolts eventually died in the weirs. Only two fish from the St. Croix River were detected in weirs, and both found their way out of the weirs and then left the bay.

Surveys near the numerous cage sites from salmon culture in Passamaquoddy Bay and around Deer Island indicated that post-smolts were not attracted to the feed or to other salmon at these sites. Although all fish successfully leaving Passamaquoddy Bay had to swim within several hundred meters of many cage sites, they were not delayed or adversely affected by these sites. Similarly, fish that were not detected leaving Passamaquoddy Bay were not detected around the cage sites. These post-smolts were considered to have died from predation near the release sites and along the coast.

The study was the first to successfully follow the movement of groups of Atlantic salmon at their early life-history stage over long distances in sea water. It was also the first to effectively seal off a large coastal area such that all fish surviving and moving through the network of sonic receivers could be detected. As a follow-up, a study will be conducted in the spring of 1996 using wild smolts from the Magaguadavic River to confirm the results obtained in 1995 with hatchery smolts. A new, smaller pinger was developed over the winter from use in wild smolts which are considerably smaller than the hatchery smolts. Prototypes of a miniature receiver designed from large-scale deployment at sea to detect movements within extensive areas of open water will also be tested.

With these advances in technology, ultrasonic telemetry could be used to address many of the questions about the migration routes of Atlantic salmon at sea and the factors that influence migration to feeding grounds. This could provide an insight into the reasons for the continuing decline of salmon stocks, especially those from the rivers of the inner Bay of Fundy. Future projects are therefore planned to follow the movement of wild Atlantic salmon smolts from the Stewiacke River, at the head of Minas Basin, in the Bay of Fundy and northern Gulf of Maine area where they are thought to overwinter (Figure 3). The 1997 study could shed important new light on the mystery of the over-wintering and feeding grounds of the salmon from the inner Bay of Fundy river which could help to explain why the salmon haven't been coming back.

Acknowledgments

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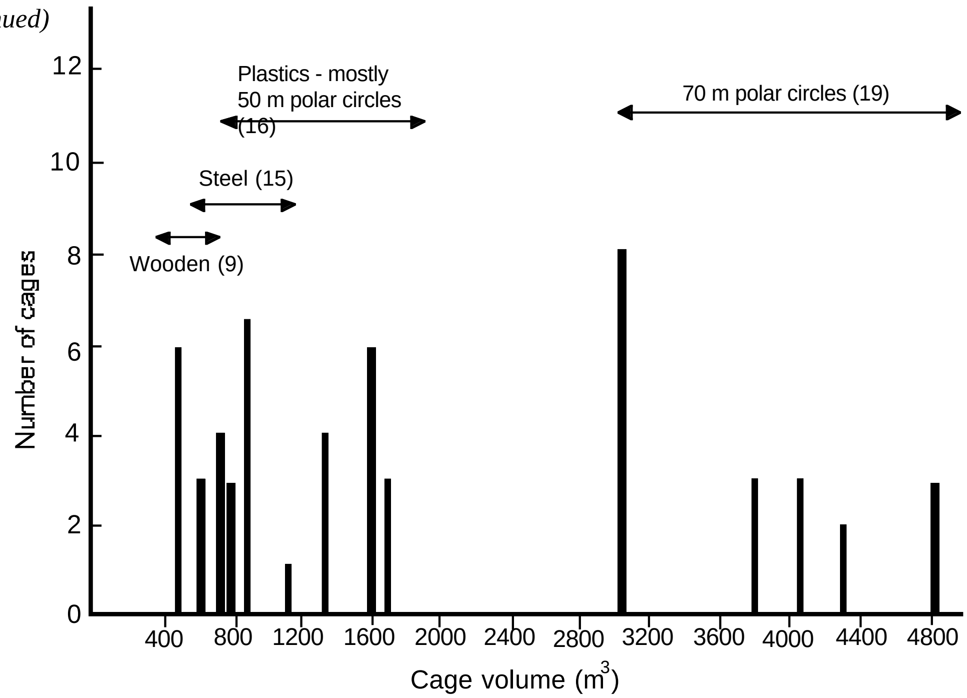

Figure 1. Salmon sea cage types monitored in the Bay of Fundy.

Cage Characteristics

The plastic 70 m circumference circular cage was the most numerous cage type monitored (Figure 1), followed by 50 m circumference circular and steel cages. The older wooden cages were used on only 3 of the 20 farms participating in the survey. Estimated cage volumes varied from slightly over 400 m^3 to about 4800 m^3. Usually 5-6 fish are reared per m^3. The mesh size is usually 11/8" mesh initially , changing to 21/4" after 12 months or so. Almost all nets are treated with an anti-foulant.

Smolts

Most smolts in the survey were "S_1" smolts - one plus years of age. The mean length of S_1 smolts was 19-20 cm (Figure 2), corresponding to a weight of 70-80 g. Smolts a year older ("S_2" smolts) averaged 23-24 cm long and *ca*.150g in weight. Sex ratio was related to smolt size. S_1 smolts <19 cm were over 60% males (N=608), while S_1 smolts > 21 cm were over 60% females. The influence of size on sex ratio is due to the precocious sexual maturation of many males at one year of age, which slows growth. Since S2 smolts are fish that did not grow quickly enough to become a smolt the previous year, these were 75% males. It will be interesting to see if initial smolt size influences the rate of grilsing in the cages, since males have a greater tendency to become grilse.

Smolts <17 cm had higher mortality rates in salinity challenge tests (96h at 37â) than did larger smolts. Salinity tolerance was not related to previous sexual maturation.

First Summer's Growth at Sea

The three factors most influential in determining specific growth rates in the first summer were time of measurement, initial smolt size, and time of smolt entry into the cage. The time of measurement is significant, because fish measured later in the summer have had warmer mean temperatures, and so have higher growth rates. Smaller smolts tended to exhibit higher growth rates the first summer than did larger smolts. Smolts introduced into the cages earlier in the spring had lower growth rates, because they experienced a longer period of low temperature at the beginning of growth.

The model developed to relate these factors to specific growth rate ((ln final weight - ln initial weight/time)¥100) is

$$G= -9.2033 + 0.007533S + 0.07431t_f + 0.00002743S^2 - 0.0001365t_f^2 - 0.00007787St_f + 0.01033t_i$$

where S is initial smolt size, t_f is time when the final weight measurements were taken, and t_i is the time when the smolts were placed in the water. The model is valid only until the third week of September, and for smolts of 140 g or less. Temperature differences among farms will also be worked into the relationship. The current model accounts for about 70% of the variance in growth rates among cages, and adding interfarm temperature differences will account for another 8-10%.

Figure 2. Summary of S_1 and S_2 smolt fork lengths in Bay of Fundy salmon cage survey.

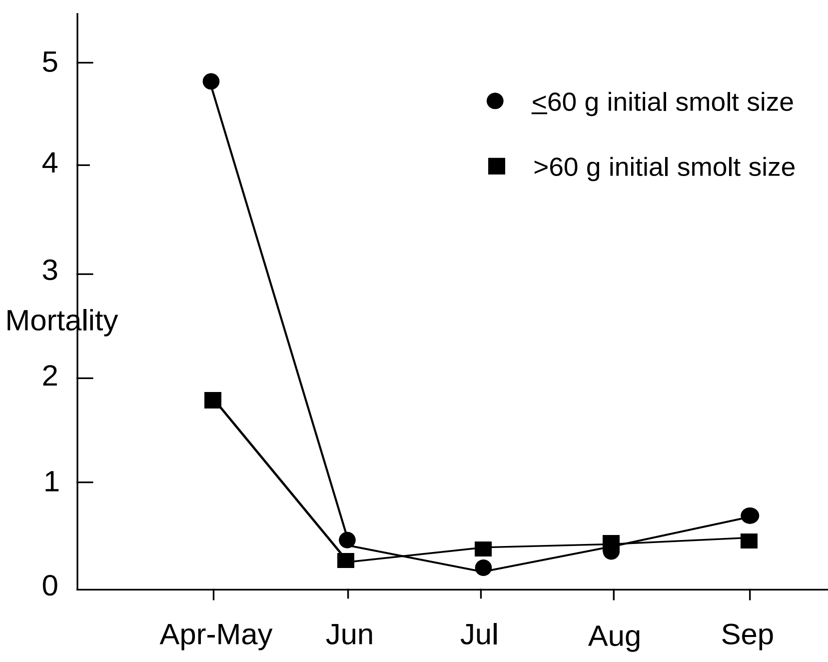

Figure 3. Mortality rates in salmon smolts from Bay of Fundy salmon cages.

Mortalities

Mortalities were highest in the first month after transferring the smolts to the sea cages (Figure 3). Smolts less than or equal to 60 g experienced greater mortalities in the first month than did larger smolts, but thereafter mortality seemed independent of initial smolt size.

Production Model

Based upon the relationships discussed above, a production model for a typical cage of 50 g smolts and one of 100 g smolts is shown in Table 1 (see next page). The increase in biomass is almost the same for the two size classes of smolts, due to the higher specific growth rates of smaller smolts. Mortalities of 50 g smolts are about twice that of 100 g smolts, but may not be very significant economically.

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(salmon growth continued)

The Shellfish Industry in the Gulf of Maine, Status and Possible Future Directions

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Projects directed at increased harvest of shellfish have been initiated in response to the decline of catches of wild stock, and the depletion or closure of traditional shellfish beds. Attention is focusing on two species which have been harvested for many decades and have provided significant earnings for many communities: the soft-shell clam *(Mya arenaria)*, and the sea scallop *(Placopecten magellanicus)*. This article will discuss current issues and future options for these two species.

Soft-shell Clams

The fishery for the soft-shell clam *(Mya arenaria)*, in the Canadian Maritimes has had a long history, with formal catch records dating back to the late 1800s. Because of its accessibility during low tides, the soft-shell clam was probably one of the first marine species to be exploited. It was also an important food source for the native tribes in the area, and the remains of this early exploitation is apparent in the many shell mounds or "middens" in the area. After colonization by the Europeans, clams continued as a basis for the food industry, first as a direct food source and later as a bait source for the lucrative long-line fishery off the Grand Banks and other groundfishing areas. At the turn of the century, fishing schooners would often stop off in the Annapolis Basin or the Quoddy region in southwestern New Brunswick to gather barrels of salted clams for bait. In the early to mid 1900s, a canning industry for clams was well established and many canned clams were exported from the Bay of Fundy.

Harvesting methods have changed little over the last century. With the exception of a brief period in the 1960s, when automated harvesting techniques were examined, hand harvesting using a clam fork (hack or digger) has been the only method used in the Bay of Fundy.

Despite this consistency in harvesting method, the landings have generally decreased. This progressive decline in landings has had a dramatic effect on the local economies. The loss to the communities can only be estimated indirectly, but gives a sense of the regional economic impact. The average harvest from the Bay of Fundy was approximately 5,700 tons from 1945 to 1955. If this biomass of clams was landed today and sold for the current price of $1.90/ kg ($0.85/lb), this would net the diggers and local economies about $10.86 million. In 1994, the total recorded landings amounted to 1191 t, which was worth $2.27 million at $1.90/ kg, a drop of 80%. In the Casco Bay Estuary Project in Maine, the clam industry was estimated to have an economic multiplier effect of about 3.5 (i.e. the additional revenue generated from the harvest of clams in the community by buying gas, food, etc.) This equates to an annual loss of $30 million in potential income to the clam industry and the coastal communities in the Bay of Fundy.

In an attempt to replace some of this lost production, a clam relaying technique was tested on Grand Manan in the fall of 1993. This involved moving clams from a contaminated area in Woodwards Cove (fecal coliform closure) to a clean, open beach at the Ross Island Thoroughfare where they could cleanse themselves. Over 92,000 clams were harvested.

The effect on the fecal coliform levels of relaying the clams to a clean, open site from a closed area was quite dramatic. The levels dropped from 2,400 fecal coliforms per 100 g of clam meat in September to 45 fecal coliforms per 100 g of clam meat 6 weeks later. This is well below the legal limit for harvesting. At the control site (Woodwards Cove), the counts also dropped, but only to 790 fecal coliforms per 100 g of clam meat, which was more than 3 times the acceptable limit.

The survival rate of the relayed clams was also quite high. Although there was a 40% drop in the number of small clams over a seven month period, the survival of the medium and large clams was good (between 90 and 100%). The economics of the transfer operation from the closed to the open areas was also favorable. Relaying over 92,000 clams cost 2 to 3¢ per clam relayed depending on whether the capital cost of the gear was included. This equated to creating jobs at a rate of $10.79 per hour assuming a survival rate of 70%.

While this project was only a single test of the relaying process, the results confirm that this type of effort has potential and that other efforts should be supported. With enough successful trials, a strong case could be made to incorporate this strategy into the soft-shell clam management plan. We anticipate that this method will allow more diggers to participate in harvesting the clams and will also have the potential to put closed areas back into production. However, this approach will only work if there are clean beaches available and there should be more incentive to ensure they remain clean and open.

Sea Scallops

The commercial industry on sea scallops *(Placopecten magellanicus)* is also quite old. Records on the scallop fishery in the Bay of Fundy date back to the late 1800s, and formal landings go back to 1949. In the Bay of Fundy, the major beds are located off the southwest coast of Nova Scotia, near Digby, but there are secondary beds extending throughout the rest of the Bay. These are probably limited by appropriate habitat. Outside, in the Gulf of Maine, the scallops are found on the offshore banks (German, Browns and Georges). The latter supports the largest wild scallop fishery in the world. Scallops are harvested by towing heavy steel rakes (or drags) with a chain-link bag over the bottom. The landings of the Bay of Fundy fleet rose from 938.4 t in 1985,

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to a record high of 4446.9 t of meats in 1989 and then gradually declined to 2253.9 t in 1994. This fluctuation in landings is not unusual. Scallops are known world-wide for their variable recruitment patterns and the instabilities these fluctuations create within the industry.

The scallop industry in the Bay of Fundy is in a state of change. Some of the major beds have been closed to harvesting for conservation reasons and the fleet is now ranging further afield. Many of the vessels now fish 24 hours per day, using double crews to maintain the desired catch rates. However, there have been some efforts made to reduce the natural fluctuations in the populations and also to increase the production of the scallop industry. Many of these initial attempts were in Japan, but other initiatives have since occurred world-wide using the Japanese technology. Two approaches have been used to boost scallop productivity: 1) intensive culture using hanging cages and 2) extensive culture where the scallops are basically seeded on the bottom and harvested two to three years later after they have grown to commercial size.

The first approach (intensive culture) has been tried on a small-scale, experimental basis in a number of areas in the Gulf of Maine. The results indicate that shell growth of the cultured scallops is faster than those of wild individuals on the bottom, and the meat size is also proportionally larger. Survival of the scallops is also high in the nets (often over 80%) as long as the animals are tended on a regular basis. Seed supply has been one of the critical factors in the development of this industry, but areas now being studied may be a good source of naturally collected spat. Hatchery technology is also available. The scallop culture industry is now at the point where pilot-scale, semi-commercial operations are required.

The second approach, extensive culture, basically bridges the gap between the wild fishery and the intensive culture industry. The concept was developed in Japan and consists of capturing wild spat using fine mesh bags stuffed with monofilament gillnet or other types of netting; placing the collected spat in suspended nets (intermediate culture) to grow the animals to 30 mm (1.2 inches), and then seeding them to fishing grounds where they will be harvested by members of the traditional fishery who are associated with the seeding effort. This type of work is going on successfully in Japan, Australia, France and the Magdalen Islands in the Gulf of St. Lawrence, and interest is now being expressed in the Gulf of Maine.

There is a slight modification to the above technique, known as direct seeding, which may also be applicable for enhancement. The process involves setting out collectors to catch the setting scallop larvae over suitable habitat and then seeding the beds with the resulting animals after they have grown to a larger size. This allows them to escape some of the predation which would have occurred from some of the smaller predators. These collectors can either be the traditional spat bags or they can be filamentous collectors which resemble “fuzzy” rope. In the bag collectors, the bags are retrieved after the early growth stage and then seeded onto the scallop beds. This is an active process on the part of the culturist, whereas the “fuzzy” rope collector is a passive process. The rope is set over a scallop bed during spawning season and the larvae settle on the filaments. Once they reach a shell height of approximately 3 mm they drop off the rope and settle on the bottom. The ropes can then be retrieved and reused the following year. Some of our research has shown that with the bag method, densities of up to 3,000 animals per bag can be collected for bottom seeding, although the density is dependent on where the spat collectors are placed. Research on the “fuzzy” rope has shown that densities of up to 400 spat per meter of rope can be achieved. We also have preliminary data which suggests that densities of adult scallops can be increased with an increase in the number of the early juvenile stages.

Therefore, the enhancement option would appear to be feasible, at least in some areas. The most demanding part of the process is creating the initial organization and obtaining the cooperation of all the involved parties.

Conclusions

The above work indicates new ways of doing business and obtaining more value from the marine environment. Some of the options relate to the wild fishery and essentially move it to the status of a “put-and-take” fishery, similar to some of the freshwater finfish species. However, it must be kept in mind that this is more than a technical process. It is also a social process and both are equally important. Without the social will to achieve the result, it will not matter whether the technology exists. For example, the soft-shell clam industry in the Bay of Fundy is reluctant to try enhancement measures for the beaches as they fear privatization of their free-ranging territory. The diggers are worried that they will be forced off the beaches by large companies that can afford to lease the best areas. No one will work to enhance a beach without some reasonable assurance that they will be compensated for their efforts, so the privatization issue is creating an impasse. Rational and creative development of the coastline is mandatory, but it must be done with a good working knowledge of the basic marine system.

This latter point is an important one. We must understand the processes operating behind these mechanisms because, without this knowledge, we can not devise effective solutions to problems when things start to go awry. Several examples highlighting this point may be found with the existing salmon culture industry. Despite the undeniable benefits the salmon culture industry has produced, it has also raised concerns over the dispersion aspects of waste and food products from the sites, spread of diseases between sites, dispersion and concentration of sea lice, impact of lethal winter water temperatures, and the dispersion and fate of toxic materials released into the water. For the shellfish industry, comparable examples would be the distribution and spread of Paralytic Shellfish Poison (PSP) and other phycotoxins in the Nova Scotia growing areas, as well as the reduction of mussel growth on Prince Edward Island in response to excessive stock-

The Recovery of Georges Bank Herring

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Historically, Georges Bank made a significant contribution to the herring landings in the Gulf of Maine. In fact, during the late 1960's and the early 1970's it supported the largest herring fishery in the western Atlantic. Unfortunately, heavy exploitation by foreign fishing fleets combined with poor recruitment during this period caused the stock to collapse in 1977. Between 1978 and 1985 virtually no adult or larval herring were detected on the bank by research surveys. The first sign of a recovery occurred in 1984 when the Canadian research vessel "Alfred Needler" collected more than 200 juvenile (age 1+) herring in a mid-water trawl (Stephenson and Power, 1989). However, it wasn't until 1986 that any significant signs were observed by both Canadian and U.S. research surveys to indicate the stock was on the road to recovery.

The Fishery

The commercial herring fishery on Georges Bank began in 1961 when the USSR landed 68,000 t of fish. Between 1961 and 1966 the USSR dominated this late summer/early fall fishery with reported landings ranging from 38,000 t to 150,000 t. The fishery expanded rapidly from 1967 when Poland and the German Democratic Republic began harvesting herring. Over the next 9 years, vessels from 12 countries, including Canada and the U.S., pursued herring in the international waters of Georges Bank (Anthony and Waring 1980). The fishery peaked in 1968 when in excess of 370,000 t of herring were reported landed from the bank (Figure 1). Catches declined rapidly during the latter years of the fishery, 146,000 t in 1975 and only 2,000 t in 1977. Between 1978 and 1983 herring had virtually disappeared from the bank. For almost 15 years no commercial catches of herring were reported from Georges Bank.

Research Surveys

Information regarding the historical status of this stock is obtained from U.S. research surveys and ICNAF stock assessments. The U.S. have undertaken a fall and spring bottom trawl survey since the 1960's and several larval surveys annually from 1971-1994. The latter survey series ended in January of 1995. Currently the spring bottom trawl survey data are used, in conjunction with other indices, to assess herring in the entire Gulf of Maine.

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Shellfish continued)

ing densities. All of these problems are based on interactions between aquaculture practices and the natural environment. With a few laudable exceptions, few scientific studies have been designed to determine how the basic environmental processes are interacting with the farm sites and animals. It is important to remember that these are only the interactions which have happened so far. There will be more interactions in the future. The common denominator of all these interactions is the basic physical and biological processes occurring in the marine environment.

There are also economic consequences of failing to understand the basic processes in which the farm sites are operating. In the development of a new species for aquaculture, lending institutions are hesitant to become involved because they see the operation as more of a high-risk venture for speculators than as a solid business-development opportunity. If the prospect of success of a new aquaculture venture is decreased because the entrepreneur has inadvertently chosen a site where unfavorable interactions occur, this will hurt the capitalization and subsequent development of the industry. The failure of a venture can also jade the bureaucratic level of government, because failures often bring political consequences when local communities lose money and initiative. Therefore, the better the match between culture operation and local environments, the more competitive and successful the culturists and their respective coastal communities. This in turn makes the traditional industries more willing to consider alternatives.

Monitoring of the recovery by Canada began in 1986 with an exploratory survey. Based on the encouraging results, an annual fall adult/larval survey which occurs shortly after the spawning season was established to cover the area most likely to show signs of a recovery. The study area was expanded in 1991 and again in 1992 to encompass most of Georges Bank east of the Great South Channel. Information obtained from the fall survey includes larval abundance (#/m^2) and distribution, spawning areas, adult size, age structure, and sexual maturity. This information is compared with theUS bottom trawl and larval survey data and the entire dataset (i.e. Canada & US) used to assess the stock status.

Two important components of the research survey data used to assess the status of Georges Bank herring are the abundance and the distribution of larvae. The larval abundance index (LAI) provides an indicator of the relative changes in abundance while the distribution of larvae indicates the spawning location and the spawning success. Since 1988 the abundance of larvae has generally increased in both the original and the expanded survey area (Figure 2). Maximum values were observed in 1994 & 1995.

The distribution of larvae has also expanded since the recovery was first observed. During the early years (1986-1989) larvae were observed primarily west of the Canada/US boundary in the vicinity of Georges and Cultivator shoals. As the recovery progressed, the distribution of larvae expanded to include most of the bank. Furthermore, the distribution of larvae < 10 mm in length, which is considered an indication of nearby spawning, broadened from a contracted area to include the pre-collapse spawning areas on the northeastern portion of the bank (Fig. 3).

Other positive signs which have been observed on the bank include the annual presence of newly recruited 3 and 4 year old fish in research samples, a broadening of the age distribution, the expansion of the area in which sexually mature fish are observed, and the recent increase in the number of herring caught per tow in the U.S. bottom trawl surveys. All of these facts have led both Canada and the U.S. to conclude that the Georges Bank herring stock has recovered, or is well on its way to recovery, from the collapse of 1977. This is consistent with the recommendation by both countries that a commercial herring fishery can re-open after a 15 year lapse.

Two hypothesis have been proposed to account for the reappearance of herring on Georges Bank; resurgence of the Georges Bank population and recolonization of the bank from neighboring populations. Stephenson and Kornfield (1990) argue that because of differences in age composition, electromorph frequencies and recovery lag time with respect to adjacent populations, there is strong evidence to support the hypothesis of resurgence. On the other hand, Smith and Morse (1990) in their analysis of 18 years of larval survey data postulate that larval transport and the gradual expansion of spawning range from Massachusetts Bay to Nantucket Shoals and finally to Georges Bank implies recolonization rather than resurgence. Both hypotheses warrant consideration, however neither is free from interpretation bias (Melvin et al., 1991).

Outstanding Issues

The main outstanding issues regarding Georges Bank herring include the approach to stock assessment and a better estimate of spawning stock biomass (Melvin et al., 1996). Currently, the assessment approaches for this transboundary stock differ between the Canada and the United States. The U.S. considers Georges Bank as one component of the "Coastal Zone Complex"(CZC) which includes the entire Gulf of Maine, while Canada assesses Georges Bank as a separate stock unit for the spawning area in 5Z. Furthermore, an analytical assessment specific to the bank is not possible due to the absence of a fishery and the resulting catch-at-age matrix. The U.S. apportions the CZC total spawning biomass estimate into three components, one being Georges Bank. Based on this approach the U.S. reports record high biomass estimates in all three units. Canada on the other hand, using conventional biological indicators and historical larval indices, conservatively estimates a spawning stock biomass in the order of 100,000 to 200,000 mt.

Regardless of the uncertainty about the absolute number of herring spawning on the bank, it is evident from the available data that Georges Bank herring have made a substantial recovery. Research efforts will continue to be directed toward improving biomass estimates and the discussion of the differences in assessment approaches in the near future.

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Stephenson, R.L., and I. Kornfield. 1990. Reappearance of Atlantic herring (*Clupea harengus harengus*) on Georges Bank: population resurgence not recolonization. Can. J. Fish. Aquat. Sci. 47:1060-1064.

Council on the Marine Environment becomes Sponsor of Association

The Gulf of Maine Council on the Marine Environment held its spring meeting on June 12-14, 1996 at the College of the Atlantic in Bar Harbor. At the meeting, the Council changed its Secretariat location to New Brunswick through next June. Mr. Bernard Theriault, Minister, Department of Fisheries & Aquaqculture, will chair the Council, with Mr. Barry Jones chairing the Council Working Group, and Ms. Megan Trites serving as staff. The present address is : Department of Fisheries & Aquaculture, Kings Place, York Tower, P.O. Box 6000, Fredericton, NB E3B 5H1, Canada; tel: 506-444-3292.

The Council made final changes to the goals and objectives for the Gulf of Maine Action Plan, 1996-2001. The Maine State Planning Office will be working with the Management Committee to finalize the Action Plan in August in order to print the document for distribution in September. The Council also approved a work plan and accompanying budget for 1996-1997. A more detailed description of work plan elements may be obtained from the Secretariat, (contact Megan Trites, 506-444-3292, e mail: megan@gov.nb.ca). It is anticipated that many projects will be put out to competitive bid. The Council approved $100,000 for NGO grants.

A key theme of the meeting was that the Council's interjurisdictional sharing of goals, effort and resources is of primary importance for implementation of the Action Plan. The Councilors have made a commitment to dedicate their departmental resources to this effort. The current EPA money, while presently a significant source of revenue, is secondary to these interjurisdictional, Council-based resources.

Other decisions of the Council with relevance to RARGOM:

1. $5,000. was approved for Association sponsorship in 1996.
2. $15,000. was approved for the two workshops that the Association is currently planning: $10,000. for this September's meeting in St. Andrews, and $5,000. for next year's management/ science workshop.
3. The Maine State Planning Office has been designated as the permanent liaison with RARGOM and the Regional Marine Research Board. This designation was made in response to concern that the Council's annual rotation of its Secretariat makes it difficult to coordinate Council activities with the scientific community.

In other Council related news, a joint proposal from the Maine, New Hampshire and Massachusetts Coastal Programs has been selected for a Coastal Service Center Fellow. The project, "Analysis of the Effectiveness of Coastal Habitat Restoration Programs in the Gulf of Maine", will be managed by Susan Snow-Cotter from the Massachusetts Coastal Zone Management Office, 617-727-9530, email: `ssnow-cotter@state.ma.us`. The project will develop a methodology, and then evaluate the effectiveness of coastal restoration projects efforts Gulf-wide.

Ecosystem Monitoring and Assessment Network Canada Enhances Atmospheric Monitoring in the Fundy Coastal Airshed on the New Brunswick-Maine Border- Joins US National Atmospheric Deposition Program/MDN

Wilfred Pilgrim, John Allen and Richard Elliot, for the Local, Regional and National Steering Committees of EMAN

An atmospheric master station is being developed to determine loading of atmospheric contaminants to the coastal environment . A variety of agencies at the Quoddy International Site of the Ecosystem Monitoring and Assessment Network (EMAN) located at the Huntsman Marine Science Centre in St. Andrews on the Bay of Fundy are involved in this effort. Marine research has been conducted at St. Andrews for over 100 years, but until now no extensive atmospheric monitoring has been attempted. To start the atmospheric component of the site, $200,000 worth of instruments have been set in place to monitor mercury (gases and wet deposition), fine particulate (aerosols <2.5microns), 26 heavy metals in aerosols, visibility and organics.

Vapour phase mercury is monitored using the most sophisticated equipment available in the world, the automated Hg Tekran instrument capable of detecting less than 1 nanograms per cubic metre. To further evaluate atmospheric loading of metals to the Gulf of Maine, the site has recently partnered with US National Atmospheric Deposition Program (NADP), the longest running and best quality assured network of its kind in North America, for a wet mercury deposition site, which will greatly aid in getting compatible data results between Canada and US. This is the first such Canada-US mercury monitoring link in this region. Quoddy is also selected as a site in the proposed international Americas Mercury Deposition Network (AMDN), which is one of the most advanced inter-continental networks ever designed for mercury. EMAN has received $15,000. from the Gulf of Maine Council on the Environment for the first, start-up year of a 5 year proposed mercury study using the NADP, with sites in New Brunswick, Nova Scotia, New Hampshire and Massachusetts. The Quoddy EMAN site is also one of 3 IMPROVE sites in Canada (Interagency Monitoring of Protected Visual Environments) which monitors visibility and metal aerosols. There are future plans to monitor wet deposition of organics, acids and metals in fog, UVB and mercury through-fall.

The EMAN framework is built on cooperation and partnerships amongst federal, provincial, university, First Nation governing bodies, industry and private agencies. There will be approximately 40 monitoring and assessment centres spread-out across Canada. EMAN is lead by Dr. Tom Brydges of Environment Canada, and is administered by the Ecological Monitoring Coordinating Office (EMCO) which was established in 1994. For further information: http://www.cciw.ca/eman/

Note: A one day Mecury Session is planned for September 20th, to follow the Gulf of Maine Ecosystem Dynamics Symposium.

U.S. GLOBEC Georges Bank Program to hold Scientific Investigators Workshop, Announces Phase 2 Projects

The U.S. GLOBEC Georges Bank Scientific Investigators' Workshop is scheduled for November 5 - 12 at the New England Center of the University of New Hampshire in Durham. This will be an intensive, eight day, data and synthesis workshop. The purpose of the meeting is not to present synthesized results, but to do the synthesis at the meeting, while working collaboratively. Additional goals include generating ideas for joint publications, suggestions for on-line data system enhancements, enhancing Scientific Investigator working relationships, and planning for 1997 field, modeling, and retrospective data acquisition and analysis. For further information, contact Bob Groman (rgroman@whoi.edu)

Twenty seven projects have been announced for Phase 2, more details, including the ship schedule, can be obtained from the GLOBEC web site:
http://globec.whoi.edu/globec-dir/list-of-phase2-projects.html

1. R. Beardsley, S. Lentz, R. Weller, J. Churchill (WHOI), *Analysis of the 1995 Georges Bank Stratification Study Physical Oceanographic Data and synthesis with Biological Data*
2. J. Bisagni (NOAA/NMFS) & P. Cornillon (URI/GSO), *Spatial and Temporal Variability in the Occurrence, Distribution and Structure of Sea Surface Temperature Fronts in the Georges Bank Region*
3. K. Brink, J. Irish, R. Beardsley and R. Limeburner (WHOI), *Long-Term Moored and Lagrangian Measurements in the Georges Bank Study: Phase II*
4. A. Bucklin (UNH), *Stage-specific distribution and abundance of the copepods, Pseudocalanus moultoni and P. newmani, on Georges Bank: life history comparisons using molecular identification of sibling species*
5. J. Candela (WHOI), C. Flagg (BNL), and D. Payne (WHOI), *The acquisition, processing and analysis of ship-board acoustic Doppler current profiling and underway sampling data*
6. A. Conversi (SUNY at Stony Brook), K. Sherman (NMFS), S. Hameed (SUNY at Stony Brook), *North Atlantic Intercomparisons of interannual patterns in zooplankton and phytoplankton species, in relation to climatic changes*
7. C. Davis, S. Gallager, and C. Ashjian (WHOI), *Measuring transport of the copepods Calanus and Pseudocalanus across the boundaries of Georges Bank*
8. C. Davis (WHOI), D. Lynch (Dartmouth), G. Flierl (MIT), D. McGillicuddy (WHOI), *Modeling biological/physical processes controlling copepod abundance in the Georges Bank / Gulf of Maine region*
9. E. Durbin (URI), J. Runge (DFO), R. Campbell (URI), C. Ashjian (WHOI), M. Ohman (UCSD), *Egg production, growth and mortality of Calanus finmarchicus and Pseudocalanus spp. on Georges Bank*
10. P. Franks (UCSD/Scripps) and C. Chen (Univ. Georgia), *Process Studies of Physical-Biological Interactions and Larval Fish on Georges Bank*
11. S. Gallager (WHOI) and H. Yamazaki (Japan), *An Experimental Evaluation of Biological and Physical Modulators of Foraging Success in Early Cod Larvae on Georges Bank-Prey Motility, Light, Depth, and Turbulence*
12. D. Gifford (URI) and M. Sieracki (Bigelow), *Zooplankton Recruitment Variability and Advective Processes on Georges Bank—Diet of Early Stage Copepods*
13. C. Greene (Cornell), M.Benfield (LSU), P. Wiebe (WHOI), *Processes controlling the recruitment of Calanus finmarchicus populations from the Gulf of Maine to Georges Bank*
14. D.Haidvogel(Rutgers),D.Lynch(Dartmouth),M.Iskandarani, *Remote Physical Forcing on Georges Bank: A Coupled Regional/Basin-scale Modeling Study*
15. P.Hassett(Ohio Univ.)(w.subcontr. P.Blades-Eckelbarger), *Dormancy in Calanus finmarchicus: individual variability in morphology, physiology and biochemical composition during overwintering in the Gulf of Maine*
16. D. Hebert (URI) and N. Oakey (BIO/DFO), *Turbulent Mixing on Georges Bank*
17. G. Lough (NMFS), J. Manning (NMFS), L. Buckley (NMFS), E. Caldarone (NMFS), L. Incze (Bigelow), *Dispersive and Advective Influences on the Survival of Cod and Haddock Larvae on Georges Bank*
18. D. Lynch (Dartmouth), F. Werner (Univ. N. Carolina), J. Loder (BIO), M. Sinclair (DFO), G. Lough (NMFS), I. Perry (DFO), F. Page (BIO/DFO), D. Greenberg (BIO), P. Smith (BIO), C. Naimie (Dartmouth), C. Hannah (BIO), C. Meise (NMFS), *Importance of Physical and Biological Processes to Population Regulation of Cod and Haddock on Georges Bank: a Model-Based Study*
19. L. Madin (WHOI) and S. Bollens (WHOI), *Field Studies on Predation Mortality of Copepods and Fish Larvae on Georges Bank.*
20. D. Mountain (NMFS), J. Green (NMFS), W.Morse (NMFS), E.Caldarone (NMFS), D.Townsend (Univ. Maine), *Broad-Scale Ichthyoplankton, Hydrography and Nutrient Studies on Georges Bank. III. Nutrients and Phytoplankton Chlorophyll.*
21. R. Schlitz, Berman (NMFS), K Brink (WHOI), C. Lee (WHOI), *Retention Processes--Moorings & Highly-Resolved Hydrography*
22. R. Schlitz (NMFS), J. Manning (NMFS), *Retrospective Analysis of Data Previously Collected from a Moored Array along the Southern Side of Georges Bank*
23. A. Solow (WHOI) and S. Bollens (WHOI), *A Retrospective Analysis of Variability in Zooplankton Composition on Georges Bank and the Northwest Atlantic*
24. B. Sullivan (URI) and G. Klein-MacPhee (URI), *Laboratory and Field Studies of the Impact of Invertebrate Predators on Fish Eggs and Larvae on Georges Bank*
25. P. Wiebe (WHOI), T. Stanton (WHOI), R. Schmitt (WHOI) and C. Greene (Cornell), *Broad-Scale Patterns of the Distirubtion of Zooplankton and Nekton in Relation to Micro- to Course-Scale Physical Structure in the Geroges Bank Region*
26. P.Wiebe (WHOI) and R. Groman (WHOI), *Program Services and Data Management for the Northwest Atlantic Georges Bank Program*
27. K. Wishner (URI) and P. Donaghay (URI), *Interaction of zooplankton vertical migration with episodic mesoscale advective features: impacts on population retention and loss*

Benthic Suspension Feeders and Flow

David J. Wildish, Fisheries and Oceans Canada, Biological Station, St. Andrews, New Brunswick

A new book entitled "Benthic Suspension Feeders and Flow" is in preparation, a collaboration between David Wildish of the St. Andrews Biological Station (Fisheries and Oceans Canada) and David Kristmanson of the Chemical Engineering Department of the University of New Brunswick. It is about those animals found on the sea floor that live by filtering small microscopic particles, called seston, which are carried to them by flowing seawater.

Typical benthic suspension feeders include such gourmet fare as scallops, mussels, and clams. A major aim of the book is to present an accessible point of entry for new research recruits into an exciting, interdisciplinary field. Because the field is relatively new, I believe that it is ready for further advances by benthic biologists, hydrodynamists/physical oceanographers, and surficial geologists, working collaboratively.

Related Literature

As a mature discipline, hydrodynamics has been interpreted for biologists in a number of research articles and books on this subject. Steven Vogel's second edition of "Life in Moving Fluids: the Physical Biology of Flow," was published in 1994 and is among the well known books. Another new book is by Mark Denny titled "Air and Water: the Biology and Physics of Life's Media," published in 1993. Other books with some overlap and a more biological focus include C.B. Jorgensen's "Bivalve Filter Feeding: Hydrodynamics, Bioenergetics, Physiology and Ecology," published in 1990; and "Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans" by local authors Ken Mann and J. Lazier of the Bedford Institute of Oceanography (Fisheries and Oceans Canada).

"Benthic Suspension Feeders and Flow" is a first attempt to provide an overview of the achievements of the interdisciplinary field mentioned above from the benthic biological point of view.

Subject Matter

One way to characterize benthic animals is by the way that they eat. There are two main types: deposit and suspension feeders. Deposit feeders ingest sediments and the associated microflora directly after the sediments have been deposited, whereas the suspension feeders capture seston suspended in flowing water. The book deals only with the latter group, which includes representatives from many phyla: corals, hydrozoans, bryozoans, brachiopods, some polychaetes, bivalve mollusks, echinoderms and crustaceans, e.g. barnacles. The apparently clear distinction between the two trophic types is complicated by the presence of a subgroup in which the members are able to switch between the two: the deposit-suspension feeders. At low flows they are deposit feeding, whilst at higher flows they switch to suspension feeding. Known deposit-suspension feeders include: spionid polychaetes, some bivalve mollusks of the family Tellinacea, as well as some ampeliscid amphipods.

As a family, the ampeliscids are tube dwellers and they use their feathery second antennae to capture food particles. This is achieved either by scraping the antennae across the sediment surface, by whirling their antennae about, or by holding them steady in the flow so that they can intercept seston and feed by passively. One local species, *Haploops fundiensis*, presumably cannot deposit feed, since its antennae are too short to reach the sediment surface from its position in its tube. Apart from some experimental work on spionids the deposit-suspension feeding group has not been experimentally studied in an adequate way.

Chapter Organization

"Benthic Suspension Feeders and Flow" is organized in nine chapters with 85 figures and 65 tables. For those biologists daunted by some of the physical terminology, there is a two hundred word glossary. Consistent with the aim to recruit new researchers, chapter 2 is devoted to discussing methods of study - simulating flow and exposing benthic animals in a realistic flow environment. Subsequent chapters deal with dispersal and settlement, mostly as larvae. This is followed by two physiological chapters which concentrate on the effect of flow on the early stages of filtration - transport of seawater past the filtration surface and seston capture. The behavioral responses of benthic suspension feeders to flow are considered and it is concluded that very little is known about this fascinating subject. Another chapter deals at the population level with the common occurrence of benthic reefs and how flow changes the feeding response of the population. Coral reefs are left out of this book because they are too vast a subject and are outside the authors' experience. The book also considers ecosystems and flow - this chapter is at the highest hierarchical level of biological organization. Consequently the authors are forced to take some liberties with the reductionist cast of the title. A final chapter seeks to provide a framework for future work which needs bright new recruits to advance this research.

Publication Date

"Benthic Suspension Feeders and Flow" attempts to provide an overview of the hydrodynamics associated with the biology of marine benthic suspension feeders, to describe current experimental methods for this interdisciplinary area and to emphasize the many unanswered questions which remain. The book will be published early in 1997 by Cambridge University Press.

Scotian Shelf and Gulf of Maine Hydrology Atlas Available

Brian Petrie, Bedford Institute of Oceanography

A temperature, salinity and density atlas for the Scotian Shelf and Gulf of Maine is available from the Bedford Institute of Oceanography. The area from Cabot Strait to Cape Cod, including the upper continental slope, has been divided into 68 subareas. Within each subarea monthly means, standard deviations, extremes and number of observations are presented in tables and graphs at selected depths (0, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500, 600, 800 and 1000 m). Plan view maps of the seasonal (15th of Feb., May, Aug. and Nov.), optimally estimated distributions of the variables are available for 6 depths (0, 30, 50, 100, 150 and bottom). A copy of the atlas can be obtained from Brian Petrie, Coastal Ocean Sciences, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, NS, Canada, B2Y 4A2. e mail: b_petrie@bionet.bio.dfo.ca

Reports Received

The following reports have been received at the Association office and are available for distribution by contacting the author.

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia Fundy Groundfish Management, Can. Tech. Rep. Fish. Aqua. Sci., 2100:vii+297pp.

Coastal Zone Canada '94 Conference Statement and Call for Action, M. Butler, L. Hildebrand, P. Lindley, B. Nicholls, J. Sponagle, G. Daborn, D. Hopper, A. Montgomery, P. Ricketts, and P. Wells, CZCA 1996, 33pp.

Moore, R. and A. Truesdale. Jan. 1996. Land Based Sources of Pollution: An Inventory of Point Sources in the Gulf of Maine, Gulf of Maine Council on the Marine Environment

New England Fisheries Planning for the Future, New England Aquarium Aquatic Forum Series Report 96-2, Mooney Seus, M.L., H.C. Tausig, and G.S. Stone, eds., 175 pp.

Grants / Sponsored Research

National Oceanic & Atmospheric Administration

National Undersea Research Center
at the University of Connecticut - Avery Point
"Research Guidance, Opportunities and Proposal Format Guidelines for 1997 Operations"
Dr. Peter Auster, Marine Program Director
1084 Shennecossett Road Groton, CT 06340-6097
(203)445-4714 **Deadline: September 1**
Research categories for which marine regional research topics are particularly encouraged include:
Build sustainable fisheries
Recover Protected Species
Sustain Healthy Coastal Ecosystems
- coastal, oceanic, deep sea, and lacustrine processes
- pathways and fates of materials
- productivity and trophic transfer processes

Predict and Assess Decadal-to-Centennial Change

Office of Oceanic Research Programs
1315 East-West Highway, SSMC3, R/ORI
Silver Spring, MD 20910
Attn: Dr. Shirley Fiske, Director
National Sea Grant Federal Fellows Program
(301) 713-2431 **Deadline:** * (usually mid-Aug. to mid-Sept.).
S21-165 Dean John A. Knauss Marine Policy Fellowship
The NOAA sponsors a program to provide educational experience in the policies and processes of the legislative and executive branches of the federal government to graduate students in marine/ocean related fields. All applicants must submit an application to one of the state Sea Grant College Programs in their area.

National Science Foundation

4201 Wilson Boulevard
Arlington, VA 22230
(703) 306-1234 (Information Center)
e-mail: info@nsf.gov, www:http://www.nsf.gov/

Directorate for Engineering
Div. of Bioengineering & Environmental Systems
S21-182 Ocean Systems
Mr. Norman Caplan, Program Director (703) 306-1318
This program seeks to advance fundamental engineering knowledge of the ocean environment and foster technological innovations related to the conservation, development, and use of the oceans and their resources in an environmentally acceptable manner. Projects should focus on fundamental or exploratory research or feasibility studies designed to advance engineering and scientific knowledge.
S21-183 Environmental Engineering Program
Dr. Edward H. Bryan, Program Director (703) 306-1318
This program supports research to correct the adverse effects of human activities on land, water and air resources. Research is supported on the diffusion, dispersion and interactions of pollutants, innovative water and wastewater treatment processes and systems, and engineering approaches to manage or eliminate pollutants that adversely affect environmental quality.
Directorate For Geosciences
Divi. of Ocean Sciences
Ocean Sciences Research Section
Dr. Michael R. Reeve, Section Head
(703) 306-1582 **Target Dates: Aug. 15, Feb. 15**
S21-188 Ocean Sciences Research
Grants are awarded to highly qualified individuals and groups of scientists to improve understanding of the sea and ocean basins.
Research categories are:
Biological Oceanography Program: Philip Taylor, Program Director, (703) 306-1587
Chemical Oceanography Program: Donald Rice, Program Director, (703) 306-1589
Marine Geology and Geophysics Program: Bilal Haq or David Epp, Program Directors, (703) 306-1586
Physical Oceanography Program: Richard Lambert, Program Director, (703) 306-1583
Ocean Technology and Interdisciplinary Coordination Program (includes instrumentation development): Larry Clark, Program Director, (703) 306-1584

Calendar

July

25	Sources, Transport, Fates, and Effects of Metals in Marine and Aquatic Ecosystems Course, MIT, Boston, MA contact: Christine Cristo, (617) 253-7041

August

1-5	"Making Connections - Global Lessons from the Gulf of Maine", National Marine Educators Assoc., UNH, Durham, NH contact: Sharon Meeker, (603) 749-1565
11-17	"Coastal Zone Canada '96" Rimouski, Quebec contact: Paule Maranda, (418) 724-1755

September

1	NURC 1997 proposal deadline contact: Peter Auster (203) 445-4714
1	Coastal Zone '97 New Directions conference abstracts due contact: Richard Delaney, (617) 287-5570
16-19	Gulf of Maine Ecosystem Dynamics Scientific Symposium, The Algonquin, St. Andrews, NB contact: Genie Braasch, (603) 646-3480
20	Mercury Session The Algonquin, St. Andrews, New Brunswick contact: Dr. Wilfred Pilgrim, (506) 453-3624

September

23-26	OCEANS 96 MTS/IEEE "Coastal Ocean Prospects for the 21st Century" Ft. Lauderdale, FL, contact: Dan White, (407) 465-2400 x.444
27-October 1	ICES meetings Reykjavik, Iceland contact: Prof. Christopher Hopkins

November

5-12	U.S. GLOBEC Georges Bank Scientific Investigators meeting, Durham, NH

Gulf of Maine Ecosystem Dynamics

A Scientific Symposium and Workshop
September 16-19, 1996
St. Andrews, New Brunswick

The regional scientific community response to the conference has been excellent, with about one hundred poster abstracts received, representing many disciplines.

You can still register for this important conference:
contact Genie Braasch at the RARGOM office, 603-646-3480
email: braasch@dartmouth.edu

Reserve your room at the Algonquin Hotel now - *Deadline for conference room rates is August 16th*

Planning documents are located on the RARGOM web page:
`http://fundy.dartmouth.edu/rargom/`

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